Pitfalls in CT Pulmonary Angiography for Evaluation of Pulmonary Embolism
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CT Pulmonary Angiography
- CTPA revolutionized assessment of PE with sensitivity up to 94%-96% and specificity 94%-100%
- Treatment decisions made based on diagnostic studies
  - If positive – anticoagulation or placement of IVC filter
  - If negative – no treatment for PE; alternate diagnosis rendered

Inconclusive outcome in CTPA
- Meta-analysis: 16 studies evaluating 327 patients with either inconclusive, indeterminate, non-interpretable, or suboptimal CTPA
- 74 patients – no anticoagulant therapy but underwent further dx w/u
- VTE diagnosed in 16.4% on follow-up
- Underscores need for F/U

Objectives
- Review common pitfalls which cause indeterminate studies
  - Technical
  - Physiologic
  - Anatomic
- Discuss pitfalls due to error in diagnosis
- Show pitfalls due to tunnel vision
- Describe pitfalls with Dual Energy CT
- Offer solutions to these pitfalls

Case: 23 y/o 450 lb woman has this poor quality study; scanned with 75 mL I-370 140kVp. What would you recommend?
A) Repeat study with increased volume of contrast
B) MRA
C) Repeat study with increased kVp
D) Another study

Moore, Ann Intern Med. 2004;141:866-874
CTPA Scanning protocol

- Exam usually performed in deep inspiration – causes hemodynamic effects which are similar to Valsalva
- Scan delay empirically set at 20 sec
- Bolus triggering – helpful in CHF, PA HTN
- Volume of contrast material
- Selection of kVp (80-120 kVp)
- Tube current modulation
- Patient characteristics

Technical pitfalls

- Motion/breathing artifact
- Improper bolus delay
- Image review in a sharp algorithm
- Improper selection of imaging parameters
- Cursor improperly placed on triggering scan

Respiratory motion artifact

- Can result in apparent termination of vessels
- Variation in pul blood flow between insp and exp causes heterogeneous arterial opacification
- Assessment of lung windows most helpful

Technical pitfall: MDCT Air Bubbles

- Can see swirling air bubbles due to full detector rotation
- Gated cardiac studies use ½ gantry rotation so slower scan speed with better spatial but lesser temporal resolution

Physiologic pitfalls

- Abnormality of venous inflow
  - Transient interruption of contrast (TIC)
  - SVC obstruction
- Extrapulmonary shunts
  - Right-to-left shunt (PFO)
- Intrapulmonary shunts
  - Unilateral increased pul vasc resistance due to extensive consolidation
Transient interruption of contrast

- Normal response to negative intrathoracic pressure with deep inspiration which venous return of unopacified blood from SVC and IVC
- More common in pregnant patients
- Amount of inflow depends on end diastolic filling pressures, and rate of inspiration

Pearls: Transient interruption of contrast

- Hyperventilating patient prior to study helps reduce venous accumulation in IVC
- Delaying initial image acquisition by at least 5 secs after insp may allow TIC to pass through pul circulation prior to imaging
- Scan from base to apex allowing at least 3 sec delay prior reaching lower lobe vessels

Physiologic Pitfall: Right to left Shunt (PFO)

- 25%-30% of all people have an insignificant PFO at rest
- Most develop no symptoms
- Under certain conditions R → L shunt develops if RA pressures exceed LA pressures
- Physiologically shunt can occur during valsalva, deep inspiration, or coughing

Imaging Findings of PFO

- Significant and early enhancement in aorta
- Attenuation values in ascending aorta ↑↑ than PA
- Reason: deep inspiration similar to Valsalva provokes sudden ↑ in RA pressure exceeding LA pressure
- Power injection may also contribute to buildup of higher RA pressures
- Results in short term R→L shunt with contrast crossing to LA
**Scanning in known PFO**

- Perform exam in silent respiration or near end expiration
- Longer scan delay
- Always use new IV
- Remember that PFO has risk of potential paradoxic embolism which occurs during sudden ↑ in RA pressure
- Beware of free floating RA thrombi

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**Paradoxic Pulmonary Embolism**

**Anatomic Pitfalls**

- Bronchovascular segmental anatomy
  - Pulmonary veins
  - Bronchi – mucoid impaction
  - Volume averaging of bronchi
- Hilar, interlobar and bronchial lymph nodes
  - Nodes smooth inner border, chronic PE smooth outer border[^1]
- Peri-bronchovascular connective tissue

[^1]: Filipk et al Seminars in Ultrasound, CT, and MRI 2004 25(2) 83-98

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**Anatomic Pitfall: low attenuation tubular branching structures**

- Pulmonary embolism
- Mucous filled bronchi
- Pulmonary veins
- Other types of vascular emboli

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**Mucoid impaction with RLL pneumonia**
Mucoid Impaction or PE?

MIP image same patient: Mucoid impaction

Anatomic Pitfall: nodes vs vessels

Fused PET CT Images
Bronchogenic Carcinoma mimicking Chronic PE

Pitfall: Errors in Diagnosis and missed incidental findings

- Mimickers of PE
  - Tumor thrombi/emboli
  - Primary pulmonary artery sarcoma
- Missed carcinoma
- Intracardiac masses or thrombus

Tumor Emboli

- Intravascular tumor emboli may present as large, acute PE
- May produce acute PHTN by vessel occlusion
- More commonly, tumor emboli are small and occlude subsegmental arteries, leading to progressive dyspnea and subacute PHTN

PE or not PE

Tumor Emboli

- Often associated with recent organizing thrombi
- Prostate and breast carcinoma are the most common causes of microemboli followed by hepatoma, carcinoma of stomach and pancreas

Manifestations of Tumor Emboli

- Large filling defects in main, lobar, and segmental
- Small subsegmental filling defects causing vasc dilatation and beading which increases over time
- Small tumor emboli may affect secondary pul lobule arterioles and have tree-in-bud appearance

Kane et al, Cancer 1975;36:1473-1482
Pleomorphic Rhabdomyosarcoma

Bland or Tumor Thrombus?

Same patient a two months later

Pulmonary Artery Sarcoma

• Uncommon cause of intraluminal arterial filling defect
• Typically unilateral, lobulated, heterogeneousy enhancing
• Heterogeneous mass expanding PA; shows extravascular extension
• May also show subpleural nodules, consolidation and pleural effusions
• Location: main/proximal PA most frequent


Intravascular Mass Characterization

• Filling defect within the LPA: pulmonary angiosarcoma
• Intravascular and extravascular tumor diagnosed without intravenous contrast material

Intravascular Mass Characterization

• Enhancing tumor & neovascularization in left PA
• Use of contrast is helpful in differentiating enhancing tumor thrombus from non-enhancing bland thrombus which may co-exist

3D FSPGR T1 Gd
Chronic Pulmonary Embolism Versus Pulmonary artery Sarcoma

27 Year old male transferred from outside hospital for embolectomy

DX: High grade myxoid spindle cell sarcoma

Intracardiac abnormality
Mixing artifact

Right Atrial Thrombus

Pitfall: Missed Diagnoses

• Extensive consolidation: DDx/Pneumonia

• Reverse Halo sign: Remember infarction is in DDX

Same patient 3 months later

Diagnosis: Missed sarcoma

Atypical presentation of acute PE

• Reverse Halo sign: Remember infarction is in DDX

• Symptoms of PE include hemoptysis
Same patient with Acute PE RLL, infarct and Pleural Effusion

Reverse Halo: acute PE and infarction

I+ thin section CT
3 mos pr to lower
Endocarditis with infected embolus

Artifact due to DECT

• Non-embolic perfusion defects in patients without PE (apical and ant seg RUL, apical portion LUL, medial seg RML)
• Motion artifact
• Beam hardening
  ➢ Related to high contrast density in vessels (BCV, SVC) and heart (RA)
• Band-like or crescent shaped
• Minimized by saline chaser and choice of craniocaudad scan direction

Case: 450 lb woman has this poor quality study. 140 kVp; 75 mL I370 contrast medium

What would you recommend
A) Repeat study with increased volume of contrast
B) MRA
C) Repeat study with increased kVp
D) Another study

Back to Initial Case presentation: 450 pound woman with non-dx CTPA study

Conclusion

• Identify reason for indeterminate study (technical, physiologic, anatomic)
• Always consider other etiologies for filling defects that mimic bland emboli
• At times given history of PE can be a distracter to other potential diagnoses
• Always consider alternative studies